WAVE – An Audio Virtual Environment

Leonel Valbom¹, Adérito Marcos² and Computer Graphics Centre³

A B S T R A C T
This paper outlines the basis and gives a description of the project WAVE that is starting in the Department of Information Systems of the University of Minho in cooperation with a research group in the Computer Graphics Centre – ZGDV, Guimarães. The project aims to set up an immersive environment of virtual reality, where the music, sound and audio (3D or not) plays an important role in a virtual musical/sound instrument for performances, education, entertainment or experimentation.

This virtual environment uses a hardware system containing two batons with wireless sensors to convert movements into MIDI messages for interaction and a computer to process graphics, MIDI and sound. The application uses three different performance workspaces one of which includes a synthesiser, another a mixer with recording/sequencing features and the third one a 3D spatial sound display. The workspaces can be used one at a time but they are always running processes in the background all of the time. In each workspace there is a control zone at the left hand side that can change the workspace parameters. The baton in the left hand of the user changes the levels of the parameters of the workspace and sometimes it assists the musical/sound performance made by the baton in the right hand in the workspace.

This virtual instrument seeks to allow simple gestures to generate musical phrases and to control the behaviour of sounds with a great degree of freedom, thus giving the user the power to manage the expressive channels and the built-in artificial intelligence techniques. This paper will address, therefore, the main concepts and architecture supporting the WAVE platform/system.

WAVE – Ένας Εικονικός Ηχητικός Χώρος

ΠΕΡΙΛΗΨΗ
Στο άρθρο που ακολουθεί περιγράφονται οι μεθοδολογικές πτυχές της εφαρμογής διάφορων ειδομαζόν τεχνικών στο χώρο της Εικονικής Πραγματικότητας, προκειμένου να εμπλουτιστούν και να επεκταθούν οι δυνατότητες μιας πλαστής αναπρόσαρκης εικονικού κόσμου. Το άρθρο περιγράφει τις αντίστοιχες τεχνικές και προχωράει στην ανάλυση προβλημάτων και λεπτομερειών υλοποίησης. Έλεγχο, παρέχονται παραβλέψεις και αποτελέσματα εφαρμογής για καθεμία από τις τεχνικές που περιγράφονται.

1. University of Minho, Department of Information Systems, Av. de Surco Campus, 4800-008 Guimarães, Portugal lvalbom@ccg.pt
2. University of Minho, Department of Information Systems, Av. de Surco Campus, 4800-008 Guimarães, Portugal marco@di.uninho.pt
3. R. T. de Paço, 996, 4800-073 Guimarães, Portugal Adérito.Marcos@ccg.pt

IMEDEO, 4, 2004

72
Since the end of the 1980s, sound technologies have played an important role in our society, not only on the educational area and entertainment, but also in musical and sound activities, where digital audio recording and the sound synthesis (among other things) had played an excellent role not only in the new conception and synthesis of palettes of timbres and dynamic, but also in the aesthetic evolution of musical domains. Throughout history the appearance and perfection of new musical instruments has been a constant activity.

Regarding the cycle of acoustic instruments new electronic musical instruments like the Theremin, the Ondes Martenot (1928), the Pianorad (1926) and the Gievelet started to appear at the beginning of 20th century. The first two of these were the most successful in the musical community, with particular prominence for the Theremin due to its innovative technique whereby the sound was initiated with the free movement of the hands of the interpreter without any mechanical associated linkages.

By the end of the 20th century there appeared a series of new instruments, using common technologies similar to those used in Virtual Reality.

One of the instruments (or interface) featured by its contribution in the difficult attempt to exceed the levels of artistic expression demanded by musical interpreters was the Digital Baton, which was conceived during the 1990 decade in the MIT Media Laboratory.

The Digital Baton explores optical tracking in real time with an infra-red ray sensor in the exterior of a digital baton, five Piezo-resistive ribbons and three orthogonal accelerometers to send information of its the position, acceleration and orientation. Some musical/sound instruments and projects use different techniques, as for example, scanning leisure to rangefinder in order to measure the position of objects in a plane. Others use an optical system to cover, the tracking of the human movement.

Along with the creation of new musical instruments and differently used techniques of tracking, not to mention the evolution of graphical computation, other technological developments appeared to exert an influence (direct or indirect) on the habits of people and the construction of the Information Society in which Virtual Reality has started to take a prominent place. These developments are:

- digital audio recording
- the sound synthesis of new timbres
- the widespread use of technology
- the widespread consumption of information of all kinds distributed through networks or digital supports
- the accessibility to the tools of musical creation and experimentation
- the possibility of the incorporation of interaction into the systems
- the possibility of using new musical languages and music patterns

In the last decades applications for the manipulation of music and sound information such as the sequencer recorder, editors and creation technologies have been developed that are capable of simulating a complete recording studio in a single home computer. These digital tools have become accessible thereby allowing qualitative experiments of techniques using the facilities of professional equipment for the pursuit of improvements in the quality of services and the graphical representation of the digital sound information.

Independently of the tracking technologies that have been explored in the virtual instruments, it has become necessary to evaluate different ways of controlling interpreters, of opening up new expressive musical channels and also of incorporating some degree of intelligence in the computer graphic interface to allow that simple musical gestures can originate and mould complex musical phrases. Simultaneously, it is important to complement these new instruments with a good visual feedback, including multiple visualisations of musical and sound information in order to allow the efficient management/interpretation of the parameters of the expressive channels while at the same time incorporating intelligent automatisms in the system.

This virtual audio environment intends to offer to different kinds of users the possibility of interacting directly in the composition, improvisation, musical exploration or even simple entertainment in order to:

- incorporate themes such as sound, music and interpretation in a virtual audio environment;
- to develop a system that can be used for entertainment and artistic education while, at the same time, being a serious tool for composition, interpretation and experimentation;
- to implement a visual, musical virtual environment capable of awakening artistic/audio skills for users with different musical abilities, different ages and different musical preferences;
- to develop a high degree of interaction with the possibility of being used by several users simultaneously.

This virtual environment, that can go from entertainment, to education or even to performance, will be able to operate with different types and styles of music, in three-dimensional ambiances, in stereo, in mono, or interact simultaneously with real time sound synthesis conserving whenever possible, sound quality and creative freedom.
Description

The design of the virtual environment respects the sequence of tasks set out by Rovan (Rovan 2000) in a study of open-air controllers in order to allow a high degree of interactivity
1. Think ahead (initial intention)
2. Initiate movement (performance gesture)
3. Gauge performance gesture through vision and proprioception
4. Hear resulting sound
5. Adjust gesture from vision and proprioception
6. Adjust intention from hearing
7. Repeat...

The movements of the WAVE users will be captured by the tracking systems, interpreted and processed digitally triggering graphical/sound representations with sound feedback that will condition the users in their making of musical decisions in real time.

WAVE – An Audio Virtual Environment

As this system aims to be used by different types of users, it was necessary to endow it with some more advanced musical functions that enable the virtual environment to be used by musical performers. This instrument may be seen as a little demanding in respect of the control exerted by the user on the system and the level of rigour and precision of movements, however, any instrument is complex and needs great practice and devotion to reach a high level of control in performance. The conception of the system took into consideration the principles enunciated by Hunt and Kirk in that the systems of control in real time must have as attributes:

- No fixed ordering to the human-computer dialogue.
- No single permitted set of options (e.g. choices from a menu) but rather a series of continuous controls.
- An instant response to the movements of the user.
- A physical and multi-parametric device as control mechanism which must be learned by the user until the actions become automatic.
- Further practice develops increased control intimacy and thus competence of operation.
- The human operator, once familiar with the system, is free to perform other cognitive activities whilst operating the system.

In the WAVE system the perception of immersion is related to a large screen that must be seen with stereoscopic 3D glasses.
The main screen is composed of three different parts. The zone on the left side, which is also the narrowest, allows the choice of the type of interaction or available module in the second (B) of the three vertical zones of the screen. Selecting a different tab, it is possible to choose to interact with a synthesizer (synth), a sound mixer (mixer) or a 3D audio simulator (3D Spac).

The third zone (C) of the screen, which has about two thirds of the total surface of visualisation, has a direct relationship with the movements of the baton in the right hand of the user and with the second system of tracking. This zone has also a graphical representation of transport controls that are used in common sound reproduction systems (« ■ ▶ ▶ ▶ ).

In this zone, the user can also play sounds, which trigger multiple visualisations of scales, frequencies or musical patterns.

The B zone contains the real time control parameters of the synthesizer, mixer or specialiser.

The synthesizer looks like a front panel of the analogue synthesizers with oscillators, resonances, filters, and some automatic effects such as different kinds of arpeggios, harmonies and scales. The performer is able to control sound synthesis parameters that are not normally controlled in its full potential. This type of control possibilities can be used in real time, creating new sounds that change in and within time and eventually other new sounds not yet found in a studio.

The mixer with eight tracks seems to be a common mixer but there are some differences. In the first insert it can manage sound files or MIDI files to play along with the performance.

Another feature of this mixer is that it can handle the surround position of the track.

These facilities allow it to play different sound or MIDI files at the same time during the performance of the user, while at the same time adding effects to the sound files played and to the sounds used by the user in the performance.

The specialiser shows in zone B of the screen the position of the sound speakers in an open space and allows their displacement in real time.

Sound sources

Fig. 3: Detail and Sound Mixer

Fig. 4: 3D Spac Screen
In the zone C of screen, the module has a visualisation of a landscape or an acoustic room that can show the changes operated in real time in zone B. It is also possible to move a sound source through a landscape, while the system lets the listener hear noises of a country landscape.

The Zone C of the screen is of prime importance, because it is here that occurs the concerns of the three-dimensional interface, and it is also where the users concentrate their activity most of the time. It is in this zone of the screen that the user drives the specialiser and triggers the notes, frequency or duration (performance screen).

In the performance screen, where the user triggers the sound, there is:

- the visualisation of scales with different degrees of complexity (an initiated user will be able to use scales with five sounds, while an advanced user will be able to use scales with 12 sounds)
- one string to allow the use of portamentos
- a set of mini sequencers for the creation of small rhythmic/melodic patterns that can be triggered at any time

The tracking of the movements of the user is made through two systems of sensors; one of them is controlled by the movement of the arms of the user, as if the user was to leading an orchestra, while the second system detects the movements of the arms of the four users placed on fixed positions.
WAVE — An Audio Virtual Environment

with the different audio signals carried to each speaker of the surround system. WAVE does not use detailed frequency-dependence of normal HRTFs, because the users do not walk or move in the environment. Instead, they move their arms and hands, thus permitting that they can correct the direction of the sound source with dedicated controls within the screen.

From a general point of view there are some guidelines in the overall system like:

- The Wave starts with some defaults, allowing the user to play music with a pre-configured style without changes of parameters or with out any previous recordings.
- All the equivalent fields have real time actualisation.
- It implements the best possible graphical resolution on the screen.
- It gives a high degree of freedom to the performer.
- It implements a graphical function with reset/bypass/panic functions.

Of course, there are some limitations in this kind of systems. The body or the sensor positions are measured/sensed without reference to any physical contact. This fact causes various design problems that researchers are trying to solve with the use of an intense amount of visual feedback and with the creation of small music scales for inexperienced users.

Also an attempt is being made to develop strategies that allow the users to achieve consistent control and repeatable results without requiring long training and specialist skills.

Conclusions and Future Work

Up to the beginning of the twentieth century, music was normally written on paper and performed with mechanical musical instruments. Today, in the Information Society, there are new tools for making music and new ways of performing.

This paper presents a musical instrument in a virtual audio environment, based on affordable, standard hardware components and using three musical elements: pitch, timbre and space, while trying to give the user an environment of great freedom and at the same time some entertainment or experimentation.

Some improvements must be made in the interface and in the interpretation of the movements of the users.

In the final phase of the project, WAVE will be tested as an instrument of musical performance, as a tool for composition, as an entertainment instrument during cultural and artistic events and as a tool for developing educational components in the artistic domain and in corporal expression. At the same time, an attempt will be made to adapt
the virtual environment so that it can be used in research and development institutions, cultural, artistic or technological performances, artistic education and in electro acoustic performances.

References

3. Dobrian Ch., in Aesthetic Considerations in the Use of "Virtual" Music Instruments.